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PHYSICS.—*A magneto-electron theory of gravitation.*[1] CHESTER SNOW. (Communicated by L. J. BRIGGS.)

This unified theory of gravitation and electricity originated in the discovery that in a world governed by the Lorentz theory (which neglects gravitation) no one could ever detect the "change" made by replacing every electric density ρ by $\rho \cos \alpha$ and adding a magnetic density $\rho \sin \alpha$, where α is an arbitrary constant. This gave rise to the conception of charge-magnitude with electric and magnetic charge as its two rectangular components, so to speak, the mode of resolution being unessential in the description of nature just as in the case of plane vector. The reflection that the Lorentz theory is not complete because it fails to include gravitation led to the following modification of this conception. The electric and magnetic charges of an electron being $\epsilon_1 < 0$ and $\lambda_1 > 0$ are of the form

$$\left.\begin{aligned} \epsilon_1 &= m_1 \cos(\pi - \alpha) = -m_1 \cos\alpha \\ \lambda_1 &= m_1 \sin(\pi - \alpha) = m_1 \sin\alpha \end{aligned}\right\} \quad (1)$$

For a proton

$$\left.\begin{aligned} \epsilon_2 &= m_2 \cos\alpha \\ \lambda_2 &= m_2 \sin\alpha \end{aligned}\right\} \quad (2)$$

These "charges" refer to their field-producing character in the Maxwell-Lorentz field equations. The necessary and sufficient condi-

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tions for the compatibility of these field equations enable us to draw three conclusions as to the constants m_1 and m_2.

1. They must be invariants.
2. They must be strictly conserved (even when we abandon the preliminary assumption that space-time is flat).
3. A physical velocity may be consistently assigned to them, which probably implies (1) and (2).

This is taken as a physical definition of "thing" or substance, without implying any metaphysical right to the exclusive "occupancy of space." It is important (for this theory) to emphasize the fact that the so-called electromagnetic energy, whose density is supposed to be $(E^2 + H^2)/8\pi$ and rate of flow $[E,H]/4\pi$, fails to qualify as substance under each of these three specifications. This concept arises when (and only when) we resort to physical averages of the field and treat matter in bulk.

Dynamics presents us with one and only one concept thus qualifying as substance, namely (invariant), mass. We accordingly identify "electricity" and "magnetism" with mass. They are measures of the strength or quantity of the substance in its field-producing character just as mass measures the same substance in its inertial aspect. If m_1 and m_2 are the masses of electrons and protons in grams, the equations (1) and (2) give their "charges" also in grams. The factor β which reduces grams to c.g.s. electrostatic units of charge is found in terms of the mass m_1 grams of an electron, its numerical electric charge ϵ, expressed in c.g.s.e.s.u., and the constant of gravitation γ, by the relation

$$\beta = \frac{\epsilon}{m_1}\sqrt{1 + \gamma\frac{m_1^2}{\epsilon^2}} = 5.4 \times 10^{17} \tag{3}$$

This follows from the fact that α is defined by

$$\tan \alpha = \frac{m_1}{\epsilon}\gamma^{\frac{1}{2}} \text{ so that } \gamma = \beta^2 \sin^2 \alpha \tag{4}$$

If ρ_1 denotes the mass density of electrons and u_1 their mean velocity, with ρ_2 and u_2 for protons, then the complete vector field E_0H_0 of the Maxwell-Lorentz field equations (macroscopic) may be resolved into two fields $E_0 = E + e$ and $H_0 = H_0 + h$, where E,H depend only upon the electrical aspect of mass and satisfy

$$\left.\begin{aligned} \operatorname{curl} H - \frac{\dot{E}}{c} &= 4\pi\left(\rho_2\frac{u_2}{c} - \rho_1\frac{u_1}{c}\right)\cos\alpha \equiv 4\pi\sigma\frac{v}{c} \\ \operatorname{div} E &= 4\pi(\rho_2 - \rho_1)\cos\alpha \equiv 4\pi\sigma \\ \operatorname{curl} E + \frac{\dot{H}}{c} &= 0 \\ \operatorname{div} H &= 0 \end{aligned}\right\} \tag{5}$$

The field e,h depends only upon the magnetic aspect of mass and satisfies

$$\left.\begin{aligned} \operatorname{curl} h - \frac{\dot{e}}{c} &= 0 \\ \operatorname{div} e &= 0 \\ \operatorname{curl} e + \frac{\dot{h}}{c} &= -4\pi\left(\rho_2\frac{u_2}{c} + \rho_1\frac{u_1}{c}\right)\sin\alpha \equiv -4\pi\mu\frac{u}{c} \\ \operatorname{div} h &= 4\pi(\rho_2 + \rho_1)\sin\alpha \equiv 4\pi\mu \end{aligned}\right\} \tag{6}$$

The mean density of electricity σ and the mean electrical velocity v are abbreviations defined by equation (5). The mean density of magnetism $\mu > 0$ and the mean magnetic velocity u are defined by (6), the latter being also the mean mass velocity, since μ differs from the mean mass density ρ only in the fact that it is $\rho \sin \alpha$. In these equations the masses and hence charges are still being measured in grams. The theory is first presented on the assumption that space-time is flat. In a later formulation we abandon this assumption and view the first statement as an approximation.

It is the writer's belief that there are no phenomena, either electrical or gravitational, which give evidence of finite volume of electrons and protons. We may treat them as point-masses. The field vectors are regarded as conveniences for expressing the mutual influence of these masses *upon each other* and *no self-destructive field* is *introduced*. The fields mean nothing by themselves; it is only the equations of mutual influence which have a meaning. These equations show that if we could pin a proton down and neglect the space-time curvature it produces, a point-electron properly aimed would approach it with finite velocity, attaining the velocity of light at the moment it passed through the first point called a proton. On the

views here presented, the two points might come to rest superposed in space-time so that if their masses were equal their electrical aspects would go into eclipse. Their inertial and magnetic (gravitational) aspects would still be distinct. The criticism that the field vectors E or h become meaningless as an electron is approached is therefore a criticism of the language used, although the description of mutual influence remains definite and finite. The volume integral of E^2 or h^2 over a volume including an electron has no mathematical or physical meaning. The corresponding physical averages $\bar{E}$, etc., of these vectors, which we use for certain ideal descriptions of matter, neglecting much of its internal motion, are finite and continuous by definition and lead to the concept of energy density *which is limited to macroscopic applications.*

In the microscopic treatment, the second members of the field equations (5) and (6) are all zero, and they are to be supplemented with a statement of the nature of the singularities in the usual manner as fluxes of E and h. Those conditions at infinity are also assumed which will exclude all solutions not of the form of retarded functions.

The expression for the force may be inferred from the suggestion made by equations (1) and (2) which is that electric and magnetic charges, although both measured in grams, are as distinct and independent aspects of mass as two perpendicular directions in a plane. In fact, while we are neglecting the curvature of space-time (so that with imaginary time its geometry is formally Euclidean), we may view it as part of a six-dimensional continuum formally Euclidean, the two new directions being called the electric and magnetic hyperdirections. They are perpendicular to each other and to space-time. The vector masses m_1 and m_2 are hypervelocities reckoned in units that are meaningless to us. All electrons and protons have the constant and unalterable components of hypervelocity as indicated in equations (1) and (2). When we ignore all the magnetic aspects of mass we are looking at a five-dimensional section which is perpendicular to the magnetic axis. With our electric component of mass we respond to the influences of other masses which are propagated to us with velocity c (in space-time) and which are produced solely by the electrical components of these masses, and represented by E,H. Our response in space-time is represented by the classical electromagnetic force $\beta^2\sigma \left\{E + \left[\frac{v}{c}, H\right]\right\}$.

In a five-dimensional section perpendicular to the electric axis all electrical aspects are ignored because they are invisible or end-on.

The field e,h arises solely from the magnetic aspect of masses, and the only component of our masses which respond to this is the magnetic component, the space-time effect being described by the force $\beta^2\mu\left\{h - \left[\frac{u}{c}, e\right]\right\}$, which is our way of describing the universal attraction of gravitation.

The mutual influences of bodies in space-time is described by the force density

$$f = \beta^2 \sigma \left\{E + \left[\frac{u}{c}, H\right]\right\} - \beta^2 \mu \left\{h - \left[\frac{u}{c}, e\right]\right\} \tag{7}$$

although in the hyperplane they appear to be without mutual influence. These two hyperdirections both stand in cylindrical relation to space-time and are so absolute as to be only pictorial for us whose experience is four-dimensional.

The meaning of equation (7) is that a particle with electric charge Q grams and mass M grams moves in the complete field according to the equation

$$M\frac{d}{dt}\frac{u}{\sqrt{1-\left(\frac{u}{c}\right)^2}} = \beta^2 Q\left\{E + \left[\frac{u}{c}, H\right]\right\} - \beta^2 M\left\{h - \left[\frac{u}{c}, e\right]\right\} \sin\alpha \tag{8}$$

If electric charge now be measured in c.g.s. electrostatic units in the field equations (5) and in the force expression (7) and (8), the term β^2 disappears and we have precisely the present-day theory of electricity, combined with a theory of gravitation. If the magnetic density μ be replaced by mass density ρ in the field equations (6), this replaces (by reason of equation (3)) the factor $\beta^2\mu$ by $\gamma\rho$ in (7) and $\beta^2 \sin\alpha$ by γ in (8). Gravitation is thus described in terms of two vectors, e,h, to which mass is related like magnetism, together with the force density $-\gamma\rho\left\{h - \left[\frac{u}{c}, e\right]\right\}$.

On the assumption that space-time is flat, the motion of a planet M with velocity u about a stationary sun M' is given by the vector equation

$$M\frac{d}{dt}\frac{u}{\sqrt{1-\left(\frac{u}{c}\right)^2}} = -\gamma\frac{M\,M'}{r^2}r_1 \tag{9}$$

where r_1 is a unit vector from M to M'. This differs from the New-

tonian law only in that Newton's equations have on the left side $M\frac{du}{dt}$, the difference being about one part in a hundred million in the case of the earth's orbit. The perturbation of one planet on another differs from Newton's by the same order of magnitude. This views the sun's influence in rendering the geometry of space-time non-Galilean as smaller than hitherto imagined.

As we do not believe that space-time is flat, the foregoing presentation of the theory must be regarded as an approximation. Its complete statement is next made in tensor form, using for this purpose the unit of time $\frac{1}{c}$, but retaining the gram for mass and the e.s.u. for charge.

The electromagnetic field is defined as usual in terms of the antisymmetric tensor $F^{\mu\nu}$ derivable from an electrical four-potential ϕ_μ,

$$(F^{\mu\nu})_\nu = 4\pi J^\mu = 4\pi\sigma_0\frac{dx^\mu}{ds} \quad F_{\mu\nu} = \frac{\partial\phi_\mu}{\partial x^\nu} - \frac{\partial\phi_\nu}{\partial x^\mu} \tag{10}$$

where σ_0 is the proper density of electricity. The gravitational field is defined by a similar antisymmetric tensor $f^{\mu\nu}$

$$(f^{\mu\nu})_\nu = -4\pi P^\mu = -4\pi\rho_0\frac{dx^\mu}{ds} \quad f_{\mu\nu} = \frac{\partial\psi_\mu}{\partial x^\nu} - \frac{\partial\psi_\nu}{\partial x^\mu} \tag{11}$$

where ρ_0 is the proper density of mass. In the microscopic treatment σ_0 and ρ_0 in equations (10) and (11) are zero at all ordinary points, but these equations serve to indicate how the electrical and magnetic (gravitational) characters of the singularities determine the two fields. The motion of a particle with mass M grams and charge Q e.s.u. in these fields is determined by

$$\frac{d^2x^\mu}{ds^2} + \{\alpha\beta,\mu\}\frac{dx^\alpha}{ds}\cdot\frac{dx^\beta}{ds} = -\frac{1}{c^2}\left(\frac{Q}{M}F^\mu{}_\alpha + \gamma f^\mu{}_\alpha\right)\frac{dx^\alpha}{ds} \tag{12}$$

which shows that even when uncharged or in a purely gravitational field f^μ_ν, it departs widely from a geodetic world-line. The two types of field equations (10) and (11) involve the geometry through $\sqrt{-g}$. The dependence of the metric tensor $g_{\mu\nu}$ upon both the electrical and magnetic (gravitational) character of the singularities is assumed to be given by the radical modification of Einstein's equation

$$G_{\mu\nu} = 8\pi\frac{\gamma}{c^2}(E_{\mu\nu} - \gamma e_{\mu\nu}) \tag{13}$$

where

$$4\pi c^2 E_{\mu\nu} = -F_\mu^\alpha F_{\nu\alpha} + \frac{1}{4} g_{\mu\nu} F^{\alpha\beta} F_{\alpha\beta} \tag{14}$$

$$4\pi c^2 e_{\mu\nu} = -f_\mu^\alpha f_{\nu\alpha} + \frac{1}{4} g_{\mu\nu} f^{\alpha\beta} f_{\alpha\beta} \tag{15}$$

It is shown that from the two apparent conflicts with Einstein's original theory, which we have in equations (12) and (13), there arises a perfect observational harmony, the rotation of perihelion of the planets and the bending of the ordinary light ray $[E,H]/4\pi$ being practically the same.

A symmetrical static solution of (10), (11) and (13) is found for the case where $x^1, x^2, x^3, x^4 = r, \theta, \phi, t$ to be given by

$$\begin{gathered} ds^2 = -p^{-1}dr^2 - r^2 d\theta^2 - r^2 \sin^2\theta\, d\phi^2 + p dt^2 \\ F^1{}_4 = -Qpr^{-2},\ F^4{}_1 = -Qp^{-1}r^{-2},\ f^1{}_4 = Mpr^{-2},\ f^4{}_1 = Mp^{-1}r^{-2} \end{gathered} \tag{16}$$

where

$$p = 1 + 2\left[\frac{\gamma^{\frac{1}{2}} Q}{c^2} - \frac{\gamma M}{c^2}\right] r^{-1} - \left[\left(\frac{\gamma^{\frac{1}{2}} Q}{c^2}\right)^2 - \left(\frac{\gamma M}{c^2}\right)^2\right] r^{-2} \tag{17}$$

This suggests the amount of light-deflection to be expected in an electrostatic field. The gravitational light ray represented by the vector product $[h,e]/4\pi$ would be deflected the same as the ordinary ray $[E,H]/4\pi$ but the former is small beyond detection. The average equation for ideal continuous matter is

$$G_{\mu\nu} - \frac{1}{2} g_{\mu\nu} G = 8\pi \frac{\gamma}{c^2} T_{\mu\nu} = 8\pi \frac{\gamma}{c^2} (M_{\mu\nu} + E_{\mu\nu} - \gamma e_{\mu\nu}) \tag{18}$$

The fact that space-time is not flat, as indicated by the deflection of the light ray $[E,H]/4\pi$ in the sun's gravitational field h shows that the six-dimensional picture which the form of this theory suggests can not be formally Euclidean. It is possible that a six-dimensional geometry might be developed which would lead to equation (13) starting from a line element of the form

$$(d\tau)^2 = g_{\mu\nu} dx^\mu dx^\nu + (\phi_\mu dx^\mu + dx^5)^2 - (\psi_\mu dx^\mu + dx^6)^2 \tag{19}$$

where the summations in μ and ν are from 1 to 4 and the coefficients ϕ_μ and ψ_μ are the electrical and gravitational four-potentials, so that

$\phi_u\, dx^u$, $\psi_u\, dx^u$, and $g_{\mu\nu}\, dx^\mu\, dx^\nu$ are all invariant to transformations of the four space-time coordinates.[2]

GEOLOGY.—*The Upper Cretaceous section in the Colob Plateau, southwest Utah.*[1] G. B. RICHARDSON, U. S. Geological Survey.

The Colob Plateau lies in southwest Utah, in eastern Iron and Washington counties and western Kane County, and extends from Cedar City and Kanarraville on the west to Orderville and Upper Kanab on the east. The name applies specifically to the bench underlain by the Cretaceous rocks, with the Eocene rocks of the Pink Cliffs rising above to the level of the High Plateaus—here known as the Markagunt and Paunsagunt—and with the bold escarpment of Jurassic and probably Jurassic rocks in the White Cliffs descending at the outer margin to the deeply eroded Triassic red beds.

The Cretaceous deposits of Colob Plateau are of interest to geologists in that they are on the western border of outcrops of the Cretaceous of the Interior Province and were very likely near the margin of the Upper Cretaceous sea in which the deposits were laid down. Some information on the Cretaceous rocks of the region has been included in several papers[2] though with but little detail as to fossils and sequence of strata. The data presented here were gathered a number of years ago and a first draft of the paper has lain unpublished for some time. No description of the Cretaceous strata of the Colob region has appeared in the meanwhile, however, and, so far as the

[2] With this form, the field equations (10), (11), and (13) show that $\overline{G}^{\mu\nu} - \frac{1}{2}\gamma^{\mu\nu}\overline{G}$ (for the six-space R_6) vanishes in all components in which space-time suffixes enter and the equations of motion (12) indicate that a charged particle follows a geodetic line in R_6. It also appears that the resolution of charge into electric and magnetic (gravitational) components is physically indeterminate, which means that we may choose these two perpendicular directions x^5 and x^6 arbitrarily in their plane, thus altering the form but not the content of our description of nature. Certain other transformations such as $x = x'^5 + U(x^1, x^2, x^3, x^4)$ do not alter even the form of that description. Electricity and gravitation combined are thus viewed as manifestations of the geometry of a six-dimensional world of which space and time are a part. A relation of this proton to the hydrogen nucleus is suggested.

[1] Published by permission of the Director, U. S. Geological Survey. Received Sept. 30, 1927.

[2] C. E. DUTTON, *Geology of the High Plateaus of Utah.* 1880; T. W. STANTON, *The Colorado formation and its invertebrate fauna.* U. S. Geol. Survey Bull. **106.** 1893; W. T. LEE, *The Iron County coal field, Utah.* U. S. Geol. Survey Bull. **316.** 1907; G. B. RICHARDSON, *The Harmony, Colob, and Kanab coal fields, southern Utah.* U. S. Geol. Survey Bull. **341.** 1909.

writer knows, no more recent field studies have been made. It seems desirable, therefore, to make available the data in hand.

The Cretaceous strata of the Colob Plateau consist of 2500 to 3000 feet of buff to drab sandstones and shales, with subordinate lenses of gray limestone and, near the base, workable beds of coal. Approximately the lower three-fourths of these beds are of Colorado age and the uppermost part of Montana, probably late Montana, age. A generalized section follows:

GENERALIZED SECTION OF CRETACEOUS AND ASSOCIATED STRATA IN COLOB PLATEAU, UTAH

Wasatch formation:
Varicolored beds of limestone, shale, and sandstone; conglomerate at base. Fresh water shells.....over 500 feet.
Unconformity.
Montana group (probably later part):
Buff sandstone and shale; conglomerate at base. Plants and fresh water shells.....about 500 feet.
Unconformity.
Colorado group:
Buff sandstone and drab shale in the east, as much as 1000 feet thick and of marine origin; hiatus in the west.
Drab marine shale in the east, as much as 1000 feet thick; changing to interbedded shale and sandstone in the west, with the shale of lesser importance.
Sandstone, shale, and coal; in the east 300 to 400 feet thick and non-marine; in the west, very much thicker and non-marine in lower part, marine in upper part. Conglomerate at base.
Total about 2500 feet.
Unconformity.
Morrison formation:
Varicolored shale and sandstone with lenses of limestone and gypsum about 400 feet.
Unconformity.
San Rafael group:
Massive gray limestone, subordinate lenses of gypsum. Marine shells about 400 feet.

The limestone of the San Rafael group yielded fossils identified by T. W. Stanton as *Trigonia* sp., *Plicatula* sp., *Cidaris?* sp., *Camptonectes* sp., and *Lima occidentalis* Meek and Hayden. These determine the age of the beds as Upper Jurassic. The overlying varicolored deposits have not yielded fossils but there is very little doubt that they belong to the Morrison formation. At present the Morrison formation is assigned by the U. S. Geological Survey with doubt to the Cretaceous though many geologists believe it better placed in the late Jurassic.

The Upper Cretaceous strata lie unconformably upon the Morrison formation with an undulating contact. The basal member consists of a variable bed of conglomerate from 15 to 30 feet thick, composed of rounded pebbles of quartzite and limestone up to six inches in diameter. Fossil plants have been found not far above this bed[3] and marine shells of Colorado age occur still higher. Its exact age and relation to the similar units in other parts of Utah, often designated Dakota (?) sandstone, are not determinable. In this paper the conglomerate will be considered as basal Colorado.

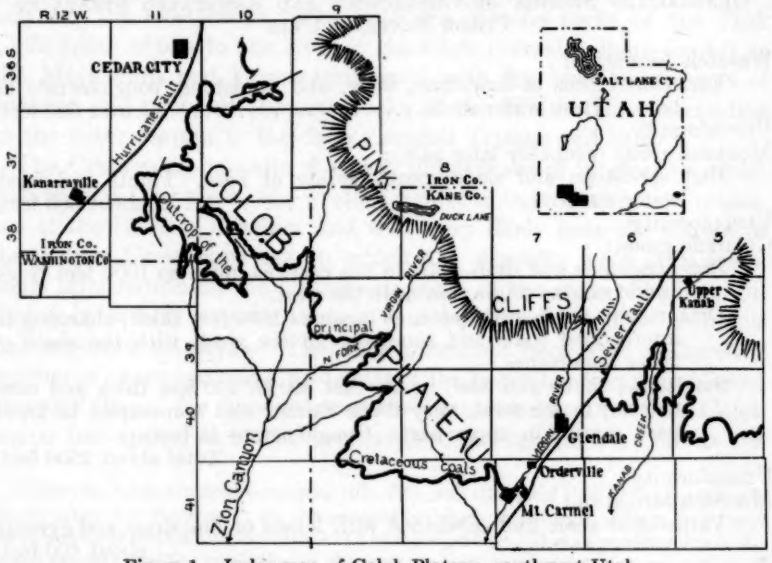

Figure 1.—Index map of Colob Plateau, southwest Utah

The rocks of Colorado age are about 2500 feet thick and above the basal conglomerate consist of buff, fine grained, quartz sandstones with much calcareous cement; buff, drab, and dark carbonaceous sandy and clayey shales; thin lenses of gray limestone; and one or more beds of coal within the lower 700 feet of the formation. The succession of strata is varied and even adjacent sections are unlike in detail. In general view, there is in the east a relatively thin coal-bearing basal sandstone unit, a middle thick shale unit, and an upper sandstone unit. Toward the west, the lower sandstone unit thickens at the expense of the shale unit and the shale unit itself

[3] T. W. STANTON, oral communication.

acquires sandstones. The upper unit is apparently absent through removal by erosion before the deposition of the overlying Montana beds. These changes result in the absence of the important shale unit in the western section, though it is conspicuous in the eastern section, as, for example, in Long and Kanab Valleys.

Faunally the Colorado group in the Colob Plateau may be divided into four units, the lower two of which are really two facies—in a broad view contemporaneous but in individual sections coming in succession. The coal-bearing beds in the lower part of the group contain littoral and brackish-water species, of which the most common, according to T. W. Stanton, to whom I am indebted for examining all of the collections of shells, are *Ostrea soleniscus* Meek, *Cyrena* sp., *Corbula nematophora* Meek, *Glauconia coalvillensis* Meek, *Eulimella funicula* Meek, *Admetopsis rhomboides* Meek, *A. subfusiformis* Meek. These species are associated at Coalville, Utah, with the principal coal bed, and most of them have been found also in the Oyster Ridge sandstone member of the Frontier formation in southwest Wyoming.

The beds above the coal-bearing zone, the lower part of the shale unit in the east and the upper part of the lower sandstone unit in the west, contain a purely marine fauna which includes among many other species the following: *Gryphaea newberryi* Stanton, *Inoceramus labiatus* Schlotheim, *Liopistha (Psilomya) meeki* White, *Turritella whitei* Stanton, *Baculites gracilis* Shumard, *Helicoceras pariense* White, *Metoicoceras whitei* Hyatt. This fauna occurs widespread in the lower Benton and equivalents, such as the basal Mancos shale of eastern Utah, New Mexico, and Colorado, and the Mowry shale and Frontier sandstone of central Wyoming. In these areas there is no zone of brackish-water fossils comparable to that described in the previous paragraph, the marine fauna constituting the first in the section, and the whole sequence of deposits is thinner. It seems very likely therefore that the marine fauna in the region to the east is contemporaneous with both the brackish-water and marine faunas of Colob Plateau and that the differing thickness is due to relative distance from the source of the sediments.

Above the zone with *Metoicoceras* a zone of upper Benton age occurs, though it is not well represented in the collections. It is best distinguished by the presence of species of *Prionotropis*. This fauna is widespread also, occurring in the lower part of the Mancos shale, in the Carlile shale, and their equivalents. In the Colob Plateau this faunal unit is in the middle shale unit.

In the upper part of the Colorado group a fauna of brackish-water

and littoral species occurs, closely related to and in part identical with that of the basal Colorado. Most of the genera are repeated and some of the species. However, at Coalville, near Manti, and in the Kaiparowits Plateau, Utah, a similar zone contains, in addition to the less distinctive species, some that indicate a Niobrara age, and it seems reasonable to infer that the upper zone in the Colorado group of Colob Plateau is likewise of Niobrara age. This zone is apparently missing in the western Colob, for the overlying fresh-water beds of Montana age descend so low in the section that they rest upon beds that include the horizons of the *Prionotropis* fauna.

Above the Colorado group lie several hundred feet of buff sandstone and shale of Montana age. A conglomerate of rounded pebbles of limestone and quartzite forms the basal unit and rests on an uneven surface of older beds. This conglomerate is about 20 feet thick on the average. These Montana beds contain fresh-water shells, among them *Unio holmesianus* White, *Viviparus panguitchensis* White, and species of *Planorbis* and *Physa*—species known in late Cretaceous beds elsewhere. Fossil plants also occur. F. H. Knowlton examined the collections and made tentative determinations, some of them being listed on page 470, but the flora is chiefly undescribed and gives little help in correlation. A similar late Montana unit of fresh water origin is present at many places in central and eastern Utah.

The next younger unit in the sequence is an irregular succession of limestone, sandstone, and shale of various colors. The contact with the underlying rocks is marked by a surface of erosion and a basal conglomerate of rounded pebbles of limestone, quartzite, and the underlying sandstone. Fossils are rare in these rocks and only fragments of *Viviparus* and *Unio* were obtained, but the characteristic peculiarities of lithologic constitution and color leave room for little doubt that they belong to the Eocene Wasatch formation so well developed in other parts of the high plateaus of Utah.

It is of interest to compare the sections in several other areas in Utah that lie near the western border of the Cretaceous of the Interior Province with that in the Colob Plateau. The section near Salina and Manti[4] shows almost exactly the same units as in the Colob. A thick lower unit, chiefly of sandstone, but containing also shale and conglomerate, has a lower Colorado marine fauna in the upper part.

[4] E. M. Spieker and J. B. Reeside, Jr., *The Cretaceous shoreline in Utah*. Bull. Geol. Soc. Amer. **37**: 429–438. 1926.

This is succeeded by shale with *Prionotropis*, and then a unit of sandstone and shale with a marine upper Colorado fauna. The Montana group is represented by a thick series of coarse-grained beds with a thin unit of coal-bearing strata near the top. The age of these Montana beds is not well established by fossils but it is believed that they are of late Montana age. At Coalville[5] the succession of strata is more complicated but the sequence of faunal units, and, in a general way, of lithologic units, is parallel to that at Salina and Manti and in the Colob. A lower unit of sandstone, conglomerate, and shale contains a lower Colorado fauna; a second of shale with minor sandstone and conglomerate contains a middle Colorado fauna with *Prionotropis;* and a third unit of sandstone and shale contains a Niobrara fauna. Above the upper Colorado beds lies a unit of rather coarse beds with a fresh-water fauna and a flora of Montana, probably late Montana, age. The succeeding beds at Coalville and at Salina and Manti are unconformable Wasatch deposits.

The following sections show the composition and approximate thickness of Cretaceous strata in Colob Plateau and the horizons at which fossils were collected:

LOCAL SECTIONS

Section of Cretaceous Rocks on Maple Creek (T. 36 S., R. 10 W.), East of Cedar City, Utah

	Feet
Wasatch formation:	
Conglomerate, rounded pebbles of limestone and quartzite.	
Unconformity.	
Montana group:	
Concealed	110
Sandstone, massive buff	50
Concealed	90
Sandstone, massive buff, containing fragments of a dicotyledon, apparently *Platanus*	70
Concealed	45
Unconformity.	
Colorado group:	
Sandstone and shale	60
Shale, drab, with thin beds of sandstone	400
Sandstone, massive buff	150
Shale	70
Sandstone and shale, alternate thin beds	100
Sandstone and shale, containing many oysters	70
Sandstone, massive buff	45
Sandstone and shale, containing many oysters	60
Sandstone, massive buff	33
Sandstone, conglomeratic, containing scattered pebbles	12

[5] C. H. Wegemann. *The Coalville coal field.* U. S. Geol. Survey Bull. 581. 1915.

Sandstone, massive buff (several layers full of oyster shells). About 500 feet above the base of the sandstone the following fossils were collected: *Gryphaea newberryi* Stanton, *Camptonectes platessa* White, *Liopistha (Psilomya) meeki* White, *Lunatia* sp., *Turritella whitei* Stanton, *Baculites gracilis* Shumard?, *Helicoceras pariense* White, *Metoicoceras whitei* Hyatt	1300
Sandstone, thin-bedded, fossiliferous	27
Sandstone, massive buff	38
Shale and marl containing the following fossils: *Cyrena* sp., *Corbula nematophora* Meek, *Glauconia coalvillensis* (Meek), *Eulimella funicula* Meek, *Admetopsis rhomboides* Meek, *Admetopsis subfusiformis* Meek	6
Coal and shale	2
Oyster bed	8
Sandstone, massive buff	45
Limestone, shaly, containing the following fossils: *Avicula gastrodes* Meek, *Barbatia micronema* Meek, *Cyrena* (?) sp., *Corbula nematophora* Meek, *Glauconia coalvillensis* (Meek), *Eulimella funicula* Meek, *Admetopsis rhomboides* Meek, *Admetopsis subfusiformis* Meek	3
Coal and shale	6
Sandstone, massive buff	
Base concealed.	
Total measured	2800

SECTION OF CRETACEOUS ROCKS SOUTH OF BLACK MOUNTAIN (T. 37 S., R. 10 W.), EAST OF KANARRAVILLE, UTAH

	Feet
Wasatch formation:	
Conglomerate, rounded pebbles of limestone and quartzite, 1 to 6 inches in diameter.	
Unconformity.	
Montana group:	
Concealed	250
Sandstone, buff	21
Shale, light	17
Sandstone, buff, containing the following plants: *Dammarites caudatus?* Lesq., *Podozamites oblongus?* Lesq., *Podozamites angustifolius?* (Eichw.) Schimp., *Platanus newberryana?* Heer, *Platanus* sp., cf. *P. primaeva* Lesq., *Betula* cf. *B. beatriciana* Lesq., *Menispermites ovalis?* Lesq., *Cinnamomum* sp., *Viburnum robustum* Lesq	11
Shale, light	15
Sandstone, buff	12
Shale, light	15
Unconformity.	
Colorado group:	
Sandstone, buff	11
Shale, drab	50
Sandstone, buff	3
Shale, drab	100
Sandstone, massive buff	15

Shale, drab, with thin beds of sandstone; contains the following fossils in the lower part: *Ostrea* sp., *Anomia* sp., *Modiola* sp., *Barbatia micronema* (Meek), *Cyrena* sp., *Corbula nematophora* Meek, *Eulimella funicula* Meek, *Chemitzia?* sp., *Admetopsis* sp	700
Sandstone, massive buff, containing the following fossils in the upper part: *Ostrea* sp., *Cyrena Glauconia coalvillensis* (Meek), *Admetopsis* sp	600
Shale, carbonaceous	17
Sandstone, buff	12
Shale, drab	35
Sandstone, buff	20
Concealed	80
Shale, carbonaceous	22
Sandstone, buff	25
Coal and shale	4
Sandstone, buff	30
Concealed	35
Shale, carbonaceous	45
Coal	6
Shale, drab	6
Sandstone, buff	8
Shale, drab	21
Sandstone, buff	5
Shale, drab	17
Sandstone, buff	15
Shale, drab	70
Sandstone, buff	6
Shale, variegated	45
Shale, buff	100
Sandstone and shale	15
Shale, buff	20
Sandstone, buff	8
Shale, drab	25
Sandstone, buff	22
Shale, sandy, carbonaceous	10
Shale, buff	100
Limestone	2
Shale, drab	11
Sandstone, buff	10
Shale, light	5
Sandstone, buff	11
Conglomerate, pebbles of limestone and quartzite	30
Total	2713

Unconformity.
Morrison formation.

SECTION OF CRETACEOUS ROCKS FROM THE HEAD OF MUDDY CREEK SOUTHWEST TO NORTH FORK OF VIRGIN RIVER (T. 39 S., R. 8 W.), NORTH OF ORDERVILLE, UTAH

	Feet
Wasatch formation:	
Conglomerate, pebbles of quartzite, chert, sandstone and porphyry (base of Wasatch?).	
Unconformity.	
Montana group:	
Sandstone, buff	40
Concealed	75
Sandstone, buff	15
Shale, light	30
Sandstone, buff	11
Concealed	40
Shale, light	17
Sandstone, buff	26
Sandstone, with lenses of limestone, containing *Viviparus panguitchensis* White, *Viviparus* sp., *Physa* sp., *Planorbis* sp.	12
Concealed	150
Shale, light	15
Sandstone, buff	5
Shale, white	22
Sandstone, buff	11
Shale, light	18
Sandstone, buff	5
Shale, light	23
Sandstone, buff	16
Shale, purplish	5
Shale, light	17
Sandstone, buff	50
Shale, light	40
Sandstone, buff	41
Shale, light	11
Sandstone, buff	17
Concealed	15
Sandstone, buff	37
Sandstone, white	7
Sandstone, buff	15
Shale, light	20
Conglomerate, small rounded pebbles of limestone and quartzite	40
Unconformity.	
Colorado group:	
Sandstone, buff	22
Shale, light	40
Sandstone, buff	100
Shale, red	5
Sandstone, buff	100
Shale, light, streaked with red	20
Sandstone, buff	53
Concealed	50
Sandstone, buff	5
Concealed	25

Sandstone, buff	8
Concealed	20
Sandstone, massive buff	200
Shale, and thin-bedded sandstone	200
Sandstone, buff	40
Shale, drab	20
Sandstone, massive buff	110
Concealed, probably chiefly shale	100
Shale, drab	60
Concealed, probably chiefly shale	100
Shale, drab	70
Coal	2
Sandstone, white	50
Shale, drab	35
Concealed	125
Coal and shale	8
Shale	50
Sandstone, white	40
Shale, purplish	5
Sandstone, white	15
Conglomerate	15
Total	2539

Unconformity.
Morrison formation.

GENERALIZED SECTION OF CRETACEOUS ROCKS IN VALLEY OF VIRGIN RIVER NEAR MOUNT CARMEL, UTAH

	Feet
Wasatch formation (?):	
Conglomerate.	
Unconformity.	
Montana group:	
Sandstone and shale, zone of fresh water shells and leaves	700
Conglomerate, pebbles of quartz, ¼ to 1 inch in diameter	10
Unconformity.	
Colorado group:	
Sandstone and shale, alternating beds, containing in the lower part: *Ostrea soleniscus* Meek, *Anomia* sp., *Cyrena* sp., *Thracia* sp., *Corbula nematophora* Meek	1000
Shale (including a few thin beds of sandstone) containing near the top: *Prionotropis* sp., *Placenticeras* sp.; and the following forms near the base: *Pecten* sp., *Avicula* sp., *Inoceramus labiatus* Schlotheim?, *Liopistha* (*Psilomya*) *meeki* White, *Dentalium* sp., *Turritella whitei* Stanton, *Baculites gracilis* Shumard?, *Metoicoceras whitei* Hyatt	700
Sandstone and shale, coal-bearing	400
Conglomerate, pebbles of limestone and quartzite, 1 to 6 inches in diameter	15
Total	2825

Unconformity.
Morrison formation.

SECTION OF CRETACEOUS ROCKS IN SINK VALLEY, SOUTH OF UPPER KANAB, UTAH

	Feet
Wasatch formation:	
Conglomerate, rounded pebbles of limestone and quartzite, 1 to 6 inches in diameter.	
Unconformity.	
Montana group:	
Sandstone, massive buff	55
Shale, drab	27
Sandstone, massive buff	30
Shale, light	6
Sandstone, massive, buff, containing the following fossils: *Unio* (casts of two or more species), *Physa* sp., *Planorbis kanabensis* White, *Campeloma* (?) sp., *Viviparus panguitchensis* White	60
Concealed (probably shale)	27
Sandstone, massive buff	33
Conglomerate, rounded pebbles of limestone and quartzite, 1 to 2 inches in diameter	27
Unconformity.	
Colorado group:	
Sandstone, grayish-white	150
Shale, purplish-drab	20
Sandstone, massive buff	65
Concealed (probably shale)	60
Sandstone, massive buff	16
Concealed (probably shale)	50
Sandstone, massive buff, fine-grained	65
Sandstone, yellowish, coarse-grained	25
Sandstone, conglomeratic; pebbles small and scattered	5
Sandstone, massive, buff	50
Concealed (probably shale)	10
Sandstone, massive buff	11
Shale, carbonaceous	7
Sandstone, buff	11
Shale, light	8
Sandstone, containing oysters	11
Sandstone, massive buff	100
Shale, drab, clayey and sandy, and local thin beds of sandstone, containing the following fossils in the lower part: *Inoceramus* sp., *Lucina* sp., *Liopistha* (*Psilomya*) *meeki* White, *Turritella whitei* Stanton, *Aporrhais prolabiata* (White), *Sigaretus textilis* Stanton (?), *Baculites gracilis* Shumard (?), *Helicoceras pariense* White, *Metoicoceras whitei* Hyatt	1200
Sandstone, massive buff	60
Shale, carbonaceous	25
Sandstone, buff	6
Shale, light	11
Shale, carbonaceous	20
Sandstone, massive, buff	25
Shale, drab	80
Coal and shale	8
Concealed (probably shale)	40

Sandstone, gray	7
Conglomerate, rounded pebbles of limestone and quartzite	15
Total	2426

Unconformity.
Morrison formation.

SECTION OF CRETACEOUS ROCKS 5 MILES NORTHEAST OF UPPER KANAB, UTAH

	Feet
Montana group:	
Sandstone, white, containing thin beds of shale	150
Sandstone, buff to white, containing: *Unio* sp., *Planorbis kanabensis* White, *Viviparus panguitchensis* White, *Campeloma multilineata* M. & H.?, *Physa* sp.	55
Shale, light	8
Sandstone, white	60
Sandstone, buff, containing the following leaves: *Cyperacites* sp., *Ficus* sp., *Laurus* sp.	42
Sandstone, white	17
Conglomerate, pebbles of limestone and quartzite ½ to 2 inches in diameter	33
Unconformity.	
Colorado group:	
Sandstone, white	145
Concealed (probably shale)	20
Sandstone, buff	5
Concealed (probably chiefly shale)	100
Sandstone, buff	5
Shale, drab	40
Sandstone, massive, buff	10
Shale, drab	18
Sandstone, massive, white	33
Concealed (probably shale)	25
Sandstone, buff	20
Concealed (probably shale)	15
Sandstone, massive buff	55
Shale, light	20
Sandstone, massive, buff	15
Concealed	40
Shale, drab	33
Sandstone, pinkish	55
Shale, light	5
Sandstone, buff, coarse-grained; locally conglomeratic	52
Sandstone, buff	43
Shale, drab	34
Sandstone, massive, buff	18
Sandstone, fossiliferous; containing: *Ostrea soleniscus* Meek, *Anomia* sp., *Barbatia micronema* (Meek), *Cyrena* sp., *Corbula* sp., *Admetopsis rhomboides* Meek, *Chemnitzia* (?) sp., *Pricnotropis* sp.	22
Shale, light	5
Sandstone, massive buff	80
Shale, drab, clayey and sandy, with local thin beds of sandstone. (Same unit as 1200-foot shale in Sink Valley section, p. 473)	
Total measured	1278

PALEONTOLOGY.—*Two new unionid pelecypods from the Upper Triassic.*[1] JOHN B. REESIDE, JR., U. S. Geological Survey.

Triassic unionid pelecypods of the United States include four species from the Dockum group of Texas described by Simpson[2] as *Unio subplanatus, U. dumblei, U. graciliratus,* and *U. dockumensis;* three species from the "Trias" (probably Chinle formation) of northwest New Mexico described by Meek[3] as *Unio cristonensis, U. gallinensis,* and *U. terrae-rubrae;* two species from the Triassic of the Connecticut Valley, *Unio emersoni* Troxell[4] and *U. wilbrahamensis* (Emerson);[5] six species from the Newark formation of eastern Pennsylvania described by Pilsbry[6] as *Diplodon pennsylvanicus, D. borealis, D. wanneri, D. carolus-simpsoni, D. yorkensis,* and *Mycetopoda diluculi;* and two species, also from Pennsylvania, described by Pilsbry[7] as *Naiadites triassicus* and *N. wanneri.* All of these are believed to be Upper Triassic.

Pilsbry considers *U. dumblei* and *U. graciliratus,* because of the radial beak sculpture, as probably referable to *Diplodon* of the South American family Mutelidae rather than to typical *Unio* of the Holarctic family Unionidae. He suggests that when well-preserved specimens are found probably all of the other Triassic species will show relationship with the South American family, and that the Unionidae proper, which certainly appear in the Morrison formation, will be found to represent a migrant element coming to North America from Asia in Jurassic time.

In the western region, in addition to the Dockum group, unionid pelecypods have been noted at many localities in Upper Triassic rocks.

[1] Published by permission of the Director of the U. S. Geological Survey. Received Oct. 4, 1927.

[2] C. T. SIMPSON, *Description of four new Triassic unios from the Staked Plains of Texas.* Proc. U. S. Nat. Mus. **18**: 381–385. 1896.

[3] F. B. MEEK, *Description of three new species of Triassic unios from the Gallinas Range, New Mexico.* Ann. Rept. U. S. Geol. Surv. W. 100th Mer., Appendix LL, p. 83–84. 1875.

E. D. COPE, *The extinct Vertebrata.* Rept. U. S. Geol. Surv. W. 100th Mer. **4(2)**: 9. *pl. 23, f. 2–7.* 1877.

[4] E. L. TROXELL, *Unios in the Triassic of Massachusetts.* Am. Journ. Sci. **(4) 38**: 460–462. 1914.

[5] B. K. EMERSON, *A new bivalve from the Connecticut River Trias.* Am. Journ. Sci. **(4) 10**: 58. 1900.

[6] H. A. PILSBRY in H. E. WANNER, *Some faunal remains from the Trias of York County, Pennsylvania.* Proc. Acad. Nat. Sci. Phila. **73**: 30–37. 1921.

[7] H. A. PILSBRY in H. E. WANNER, *Some additional faunal remains from the Trias of York County, Pennsylvania.* Proc. Acad. Nat. Sci. Phila. **78**: 26–27. 1926.

The "Popo Agie" beds (Jelm formation), the Dolores formation, and particularly the Chinle formation have yielded them. These formations contain a similar fauna of vertebrates and are probably of about the same age. No unionids have been found in the earlier Triassic deposits.

A form from west Texas and one from northeastern Arizona, each represented by a single specimen in the collections of the U. S. National Museum, do not fit any of the described species and seem worthy of record as new. Both are of types not before noted in the western Triassic, though apparently paralleled by forms in the eastern region. Because of radial beak sculpture rather than concentric they should both be assigned to *Diplodon*, but the specimen from Texas seems to the writer to be very much like some of the highly sculptured types of Cretaceous Unionidae for which Pilsbry proposes the name *Proparreysia*.[6]

Diplodon? haroldi Reeside, n. sp.

Figure 1

Shell suboval, small; beak small, subcentral; posterior and anterior ends both broadly rounded.

Sculpture of two sets of moderately strong ridges intersecting at an angle of about 60° on a line passing from the beak to the basal margin slightly posterior to the middle of the shell. The posterior slope has the strongest corrugations, the anterior and basal parts few or none. Basal part shows several coarse concentric ridges.

Hinge not preserved.

Length and height, as preserved, 35 and 25 millimeters; probable complete length and height, 40 and 30 millimeters.

Collected by Harold J. Cook in 1925 in Mitchell County, Texas, in the southeast corner of the Staked Plains. Dockum group.

This species is distinguished by its suboval form and by its relatively complex sculpture, resembling in some respects that of *Diplodon wanneri* but recalling much more that of such later species as *Unio* (*Proparreysia*) *holmesianus* White.[8] It is really not very close to any of the described Triassic forms.

The associates of *D.? haroldi* at the locality of occurrence were *Unio dockumensis*, *U. graciliratus*, *U.* cf. *U. dumblei*, and some reptilian remains

Diplodon gregoryi Reeside, n. sp.

Figure 2

Shell small, suboval; beak fairly prominent, subcentral; anterior end narrowly rounded, posterior end rather broadly rounded.

[8] C. A. WHITE, *Contributions to paleontology. No. 4. Laramie.* 12th Ann. Rept. U. S. Geol. Surv. Terr., p. 67, *pl. 22, f. 4.* 1880.

Sculpture of about 15 nearly equal, broadly rounded radial ribs, with narrow shallow grooves between. Concentric sculpture weak except on the basal part. The radial ribs are weak or absent on the basal part of the shell.

Hinge unknown.

Length and height, as preserved, 13 and 11 millimeters; probable complete length and height, 16 and 12 millimeters.

Collected by H. E. Gregory in 1911 in Beautiful Valley, Navajo Indian Reservation, Arizona. Shinarump conglomerate.

This species is characterized by its form and its radial sculpture. No close relatives are known in the western Triassic. In the eastern Triassic *Diplodon pennsylvanicus* seems to be the closest, though it differs sharply in the anterior position of the beak and in the outline of the valve. *D. borealis* has a different type of sculpture, with its broad flat ribs and very narrow interspaces.

Figure 1 —*Diplodon? haroldi* Reeside, n. sp., lateral and anterior views of type specimen, natural size (upper figures). Dockum group, Mitchell County, Texas. U. S. Nat. Mus. Cat. No. 73450.

Diplodon gregoryi Reeside, n. sp., lateral and anterior views of the type specimen, × 2 (lower figures). Shinarump conglomerate, Beautiful Valley, Arizona. U. S. Nat. Mus. Cat. No. 73451.

In the form and sculpture, *D. gregoryi* suggests strongly some marine species allied to *Cardita*, so much indeed that it was at first thought to be a marine species[9]—a very plausible assignment in view of the facts that carditoid shells are abundant in Mesozoic deposits, the specimen was accompanied by only fragments of other shells, and nothing remotely like it had been reported from fresh-water deposits in North America. There seems little reason now to doubt that it is a fresh-water fossil, and that its habitat was such as to conform to the current interpretation of the conditions of deposition of the Shinarump conglomerate.

[9] H. E. Gregory, *The Navajo Country*. U. S. Geol. Surv. Prof. Paper 93: 41. 1917.

SCIENTIFIC NOTES AND NEWS

Prof. LEON W. COLLET, Professor of Geology and former Dean of the Faculty of Science at the University of Geneva, Switzerland, who will fill Prof. R. A. Daly's chair at Harvard University during the first half year and during November will deliver a course of lectures at Princeton University, visited the Geological Survey in September and conferred on problems of tectonics and sedimentation with members of the Survey. Prof. Collet will visit Washington again in November, at which time he will address the local geologists. Prof. Collet's new book on *The Structure of the Alps* has just been issued.

Dr. E. SEIDL, of Berlin, mining engineer and geologist, known for his studies of the salt domes and potash mines of central Germany, in September presented to members of the U. S. Geological Survey his views on the bearing of salt structures on the interpretation of the structure of parts of the Alps.

Dr. D. J. MUSHKETOV, Director of the Geological Survey, U. S. S. R., who is visiting the United States to gather data on organization, administration, methods of work, publication, costs, etc., in connection with geologic work, spent some days in early October at the U. S. Geological Survey. He later attended the meeting of the Association of the State Geologists at Urbana, Illinois, and on November 2 spoke before the Geological Society at Washington.

The National Academy of Sciences met at Urbana, Illinois, on Tuesday, Wednesday, and Thursday, October 18, 19, and 20. G. P. MERRILL, U. S. National Museum, DAVID WHITE, U. S. Geological Survey, and C. S. HUDSON, Bureau of Standards, read papers and A. L. DAY, Geophysical Laboratory, gave the evening lecture, open to the public, on the subject *The volcano problem*. Papers dealing with psychology and biology were given on Tuesday afternoon; botany and zoology in one section, and physics and chemistry in a second section, on Wednesday morning; and chemistry and geology on Thursday morning.

The Association of State Geologists met with the National Academy at Urbana on Thursday morning, October 20, and on Thursday afternoon continued its meetings in the offices of the Illinois State Geological Survey. The following day was given over to an excursion to points of geologic interest. W. C. MENDENHALL and DAVID WHITE, of the U. S. Geological Survey, and G. P. MERRILL, of the U. S. National Museum were in attendance.

M. R. CAMPBELL, of the U. S. Geological Survey, during the second week in October gave four lectures at the University of Pennsylvania as part of a comprehensive course on Fuel Engineering just instituted. This course is to be given by some 50 specialists, each of whom will discuss the aspect of the subject with which he is particularly familiar. Mr. Campbell's lectures dealt with *Coal, lignite, and peat resources.*

The meeting of the Section of Geodesy of the International Geodetic and Geophysical Union at Prague was the most successful one that has been held since the Union as organized at Brussels in 1919. Delegates were present from 25 countries and 4 other countries were represented by proxy. The meeting of the Executive Committee was held on August 29 and 30, while the Section as a whole began sessions on August 31. The formal opening of the Union occurred on September 3. The outstanding report was that on work done by Dr. F. A. Vening Meinesz, Engineer of the Dutch

Geodetic Commission, in determining gravity at sea in a submarine of the Dutch Navy. In 1926 he traveled by submarine making gravity observations en route from Holland to Java, across the Atlantic and the Pacific and through the Panama Canal; in previous years he had made gravity observations from Holland to Java on a submarine through the Mediterranean Sea and the Indian Ocean. The reports from the United States and Canada showed much work done in the field and in the office since the Madrid reports and give accounts of new instruments and methods.

In the Section of Terrestrial Magnetism and Atmospheric Electricity interesting reports were received from many of the 27 nations represented at the Congress. Proposed French work in Indo-China and in the Pacific was of special interest. Reports from the United States, including that of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, were complete and the latter, especially, was filled with valuable material in regard to international work. Important subjects discussed included magnetic characterization of days, adoption of Greenwich time in observatory publications, advancement of auroral studies for which a committee was appointed including Sir Frederick Stupart, and Commander N. H. Heck, and geophysical methods of studying surface geological structures for which a committee including Mr. J. A. Fleming was also selected. Dr. Louis A. Bauer was elected president of the section.

In the Section of Seismology national reports of considerable interest were presented, especially that of Dr. Imamura for Japan who also discussed results obtained with the long period seismograph. Reports showed that the United States is rapidly taking its proper place in the investigation of seismological problems; a report for the Government, submitted through the Coast and Geodetic Survey, gave a comprehensive statement of all the activities in the United States, governmental and otherwise. Detailed reports described the reports of the Carnegie Institution of Washington and the Jesuit Seismological Association.

The work of the Section of Oceanography was chiefly a statement of steps taken in the attempt to coordinate the activities of the Section with those of other organizations. The possibilities and limitations of such cooperation were brought out. It was pointed out that a recent accomplishment of the Section was a preparation of lists of oceanographers and oceanographic institutions throughout the earth, publications of great value to those engaged in oceanographic work.

With one exception eight sessions of the Meteorological Section were presided over by Sir Napier Shaw of London. A report of the Bureau of the Section showed that pyrheliometers had been purchased for installation in Samoa, Spitzbergen and Belgian Congo, and four special photometers designed by Richardson for measuring the Earth's albedo from airplanes were ready for distribution. New subjects discussed included the publication of upper-air data, the adoption of the week as the unit of time for meteorological summaries and a common unitary system for all the sciences comprised in the Union. The American delegate, Dr. H. H. Kimball was named chairman of a commission to arrange for better standardization of instruments and methods employed in radiation measurements.